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ABSTRACT

Problems encountered in teaching multiple linear regression forecasting are described, and methods of dealing with such problems are outlined. Problems discussed include: (1) the irrelevance of instructional exercises, (2) data base sizing as a major area of regression "unreality", (3) difficulties in locating or using actual data, (4) neglect of prediction formula accuracy in favor of the multiple regression coefficient, (5) lack of computer assistance in calculation of problems, (6) rigid adherence to the scientific method in presentation of regression forecasting, (7) failure to stress the importance of interpretation of the statistical solution reached, (8) lack of emphasis on written reports to explicate and expand upon statistical results, (9) lack of emphasis on the oral presentation of results, and (10) lack of peer evaluations of oral presentations. (TJH)

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MULTIPLE REGRESSION ANALYSIS AND REALITY-BASED TEACHING: THE TEN ESSENTIALS

A paper presented at the
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MULTIPLE REGRESSION ANALYSIS AND REALITY-BASED TEACHING: THE TEN ESSENTIALS

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Teaching multiple regression forecasting is tough. Teaching it in a way in which students view as "relevant to the real world" is tougher. And teaching it by methods that truly motivate students into higher levels of critical thinking may seem the Utopian dream. Yet, we CAN reach upper levels of learning processes in our teaching presentations of multiple regression analysis, with the right approach.

Students (and professors) have, or should have, by now become weary of "textbook scenario" regression problems. Of course, such case studies have their place in the infancy stages of learning key concepts, but once a rudimentary knowledge of the regression process has been absorbed, most texts fail in presenting truly realistic exercises. In addition, professors may often fall short of demonstrating realistic scenarios, initially in terms of exercises, and secondly, in the practical interpretations of results. Students are usually quick to recognize these pragmatic shortcomings and view regression as yet another impracticality integral to their academic experience, and, in short, they lose interest.

If we can specifically define an "unrealistic" multiple regression scenario, perhaps creating a "realistic" one is not far behind. This author has developed the **TEN ESSENTIAL ELEMENTS** in teaching multiple linear regression forecasting at the junior, senior or graduate levels; they are enumerated below:

1. <u>The "Who Cares?" Syndrome in Regression Forecasting</u>

Problem:

The textbook and/or instructional exercises are so irrelevant that creating the regression formulas and making predictions seem meaningless, even if done with scientific accuracy.

Solution:

Develop realistic case studies in multiple regression. This can be accomplished in many ways. One approach shown to be successful in the past has been to allow students to develop their own research ideas. An important tangential benefit to this method includes the demand of critical thinking placed on the student. Many students, particularly those at the graduate level, may find innovative ways to apply regression procedure to career related activities. The greatest net result of student-created regression problems is a recognition of the practical use and value of the technique.

Used in the past with the excellent results, allow student to form "project teams" en route to a final MLR term project. Optimal

group size has been found to be three to five students. The division of labor tends to create a more "do-able" and larger scale study, with greater practical worth and impact to students. It is important however that groups are held accountable for their individualized, as well as collective, efforts. Final MLR reports (i.e., term projects) must include an "authorship page", signed by all group members delineating individual contributions and grading options (example provided in Table 1.)

TABLE 1

AUTHORSHIP CREDITS

1.	Idea for project and predicting variables:	All five of us equally
2.	Research for data collection:	Original data was equally collected among all five of us, final 100 month entry figures were secured by Maggie McCrary and Rob Sosnitza
3.	Research and writing of introduction (Part I.A.):	Linda Kreuter
4.	Research and writing of hypothesis (Part I.B.):	Janice Denton
5.	Research for data variables:	All five of us equally
6.	Input data into H.S.D. program:	All five of us equally
7.	Running H.S.D. program:	All five of us equally
8.	Analyzing runs:	All five of us equally
9.	Writing for findings:	Jo Anne Lane
10.	Writing for conclusions:	Janice Denton Linda Kreuter Jo Anne Lane
11.	Writing for recommendations:	Maggie McCrary Rob Sosnitza
12.	Summary tables:	Linda Kreuter Jo Anne Lane Maggie McCrary
13.	Graphs:	Linda Kreuter Jo Anne Lane
14.	Typing of paper:	Linda Kreuter
15.	Final document preparation:	Linda Kreuter
16.	Preparation of class handout:	All five of us equally

DRAFT 6.1/10

2. Data Base Size and Regression Forecasting

Problem:

Other than for teaching initial rudiments, data base sizing can be a major area of regression "unreality". As an example, attempting to predict a dependent variable from two independent variables across only five cases is flatly absurd in the real world.

Solution:

During instruction of applied multivariate techniques, it is imperative to stress the importance of sample size. A simple academic "rule of thumb" is: a minimum of ten cases for each independent variable in the analysis. Thus, a study to predict "y" from six independent variables would need a minimum of sixty cases.

3. Data Base Availability and Regression Forecasting

Problem:

On many occasions, students have creative ideas for regression applications, but are insensitive to the potential problems in locating and/or using the actual data needed. Often, the data, either in quantity or quality, can not be located; students will become frustrated and lose interest.

Solution:

During class lectures, discuss and illustrate various statistical data sources. A trip to the campus library to indoctrinate students to various government, business, education and social data sources can help novice regression researchers tremendously; experience shows this to be time well spent. In addition, new micro-computer databases have revolutionized personal computer potentials for both students and research practitioners. All data bases should be presented in the final report appendix, as shown in Table 2.

Another aspect involves not the existence of data but, moreover, its availability to the student researcher. Examples might include financial data from a student's employer. It is important to present these possible data availability barriers to students BEFORE they encounter them on their own. A discussion of regression analysis as it relates to top level management decision-

making (at least as applied to business applications) is important here. Students will recognize that the type of regression analysis they desire has great potential worth, as demonstrated by the fact that the needed data exists only at the highest levels of their organizations. Discussion of confidentiality issues in data base development also fit in well at this point.

TABLE 2

SE	CPI	SSCASE	UNEM	DIV	POP	OFFENS	UNITS
1.	236.400	1605.000	16.100	41.000	134.619	8.468	401.000
2.	239.900	1570.000	15.700	37.000	134.786	8.471	417.000
3.	242.400	1520.000	15.100	52.000	134.911	8.369	455.000
4.	248.000	1469.000	13.900	52.000	134.993	8.482	445.000
5.	248.900	1618.000	12.800	55.000	135.076	8.399	426.000
6.	255.800	1529.000	12.800	73.000	135.167	8.493	478.000
7.	252.100	1590.000	13.600	51.000	135.256	8.512	501.000
8.	253.800	1510.000	12.600	33.000	135.381	8.537	541.000
9.	257.700	1535.000	14.100	50.000	135.503	8.524	553.000
10.	261.400	1597.000	15.100	57.000	135.552	8.539	590.000
11.	263.600	1405.000	15.300	45.000	135.620	8.548	616.000
12.	265.500	1545.000	17.900	45.000	135.660	8.571	597.000
13.	264.400	1304.000	17.700	44.000	135.734	8.342	623.000
14.	265.500	1289.000	16.800	28.000	135.816	7.947	647.000
15.	263.600	1210.000	15.100	63.000	135.909	7.736	631.000
16.	268.000	1189.000	13.800	57.000	135.989	7.240	685.000
17.	271.300	1156.000	15.700	58.000	136.083	7.001	703.000
18.	275.900	1171.000	14.100	42.000	136.181	7.138	692.000
19.	278.900	1481.000	13.900	40.000	136.260	6.410	717.000
20.	279.100	1478.000	14.900	39.000	136.324	6.221	728.000
21.	280.200	1378.000	14.800	26.000	136.371	5.902	751.000
22.	278.200	1391.000	14.900	45.000	136.422	6.334	772.000
23.	276.400	1335.000	15.100	40.000	136.477	6.526	743.000
4.	275.100	1217.000	14.100	44.000	136.538	7.178	698.000
25.	277.800	1239.000	12.700	28.000	136.601	7.251	736.000
26.	274.800	1200.000	14.500	43.000	136.665	7.538	701.000
27.	275.100	1262.000	12.800	40.000	136.759	7.646	678.000
28.	280.300	1213.000	11.500	46.000	136.860	7.781	693.000
29.	282.700	1271.000	12.300	62.000	136.929	7.829	669.000
30.	286.000	1241.000	14.000	53.000	137.050	7.976	671.000
1.	289.300	1299.000	13.600	43.000	137.112	8.490	662.000
32.	289.300	1351.000	11.000	47.000	137.178	8.501	633.000
33.	291.200	1374.000	10.000	51.000	137.257	8.620	687.000
4.	291.200	1364.000	11.400	45.000	137.312	8.780	745.000
5.	292.100	1242.000	12.300	38.000	137.334	8.843	774.000
36.	288.700	1179.000	10.500	42.000	137.372	9.224	738.000
7.	288.000	1034.000	12.700	48.000	137.457	8.808	758.000
8.	287.100	1039.000	10.600	27.000	137.531	8.626	769.000
39.	289.800	1069.000	10.400	47.000	137.633	8.431	781.000
40.	295.000	1059.000	10.700	32.000	137.691	8.509	803.000
1.	298.000	1039.000	11.000	41.000	137.802	8.220	814.000
42.	300.700	1022.000	10.900	41.000	137.866	8.301	773.000
43.	303.800	1016.000	11.800	41.000	137.936	8.316	749.000
4.	303.700	999.000	9.200	43.000	138.001	8.278	743.000
5.	299.200	946.000	9.200	30.000	138.126	8.203	762.000
46.	298.200	971.000	8.800	51.000	138.218	8.135	703.000
7.	301.800	922.000	7.900	38.000	138.273	8.079	731.000
8.	301.300	961.000	6.300	45.000	138.296	7.886	714.000
9.	302.700	949.000	9.000	31.000	138.365	8.126	740.000
0.	304.700	1018.000	8.300	38.000	138.411	8.232	759.000
1.	302.900	1014.000	9.500	33.000	138.496	8.109	732.000
52.	298.600	1012.000	8.300	42.000	138.555	8.375	771.000
53.	298.300	951.000	9.200	36.000	138.660	8.492	742.000
4.	297.000	928.000	9.400	38.000	138.731	8.718	788.000
55.	298.300	880.000	9.900	50.000	138.801	8.449	776.000

4. Statistical Measures within the Regression Forecasting Procedure

Problem:

Teaching regression should emphasize prediction formula accuracy, as related to the real world. Stressing merely the multiple regression coefficient is inadequate toward this end. The beginning regression student is often focused solely on the R-coefficient, knowing little of the number's meaning or utility.

Solution:

In addition to the R-coefficient, emphasis must be placed on the practical predictive abilities of the forecast equation. The optimum way to achieve this is through a student understanding of standard error of estimate. Applying standard error of estimate to subsequent predictions best demonstrates regression forecasting's true utility.

It follows then, that the statistical components of standard error be equally stressed by instructors. Hence, standard deviation of the dependent variable and its importance to practical regression forecasting accuracy should be addressed. Student must understand, in both practical and theoretical terms, the relationships between the R-coefficient, standard error of estimate and standard deviation of the dependent variable in order to fully comprehend the components of predictive "accuracy".

5. Problem-Solving Techniques in Regression Forecasting

Problem:

From a pragmatic standpoint, is it essential for students to calculate multiple regression problems by hand? This tedious process at best serves students only as a review in solving simultaneous linear equations and in executing the principles of high school algebra. By the time the student arrives at a "final answer", usually in the form of b-weights, the constant value and R-coefficient, there is little interest left in actually USING the results for anything, let alone establishing opportunities for critical thinking! (See also point seven within this paper.)

Solution:

Even at introductory levels, the use of computerized regression forecasting should now be mandatory. In today's practical applications, "by-hand" analysis is unheard of; instead, spend the time saved doing classroom exercises that demand interpretive thinking. Often, "critical thinking circle discussions", during scheduled class time, yield great rewards for students, who are now allowed an excellent opportunity to interact and compare or contrast their interpretations of various regression forecasting results. Let class arguments regarding MLR interpretation flourish!

6. Viewing Regression Forecasting as More than a "Scientific" Process

Problem:

Many times the presentation of regression forecasting involves strictly the scientific method. This is, in fact, totally unrealistic relative to regression use in the practical world.

Solution:

While regression forecasting is certainly rooted well within the definitions of quantitative science, much instruction tends to minimize many of the subjective aspects of the procedure. In doing this, the gap between theory and application widens considerably. It is crucially important to present regression forecasting as having both strong objective AND subjective elements. Examples of each, interjected during class lectures and student interaction sessions, are essential.

Students should be led to recognize that MLR subjectivity occurs in the areas of hypothesis testing/alpha level establishment, choice of variables (either dependent, independent or both), decision of regression forecasting method to be utilized, and evaluations of R-coefficient and standard error of estimate quality.

Does all this subjectivity "contaminate" regression forecasting? Scientifically speaking, well, yes. But subjectivity's role, as sampled above, is part of the reality of the procedure. To teach regression forecasting in strictly quantitative terms may be true to pure science, but is false to reality.

7. Interpretations of Statistical Results

Problem:

Students often wonder, "What does this all really mean?" The "end product" in practical regression analysis must involve student interpretations. In specific terms, what does the statistical solution mean? What implications or practical recommendations could be made? How has the regression study been limited in its value? What might improve future regression analyses of the topic? Answers to each of these questions should be made mandatory in any MLR instruction.

Solution:

Student understanding of the powerful uses of MLR in practical situations is best exemplified via multiple runs using the same database. A major problem here is often the student's lack of organization; this leads to an unclear understanding of how MLR truly works. The remedy lies in the mandatory use and presentation of the MLR Summary Table and other graphics. Ideally, these graphics would be integral to the final report and should include statistical information, organized by run identification number. At a minimum, the statistical indices should include the variables used in each particular run, the R-squared value, standard error of estimate and identifying comments.

From the MLR summary table and other graphics students can more easily view the comparative changes in their results across multiple runs. From here, student interpretations come much more realistically and naturally. (See sample MLR Summary Table and other graphics in Tables 3A and 3B.) As described earlier (under point 5), a "critical thinking circle discussion" facilities students' interpretive interactions and should be strongly fostered.

TABLE 3A

SUMMARY TABLE FOR 100 ENTRIES
MEAN OF Y: 538.978

RANKED BY HIGHEST STANDARD ERROR

RUN #	R-SQUARED	SE	% MISSED	10% RULE	X COUNT	X'S USED
5	41.33	88.673	12.2	16.45	7	GSP, STE, COM, OUT, DCR DPI, CPI
7	49.37	82.821	10.96	15.37	8	GSP, STE, COM, OUT, DCR, DPI, CPI, UPL
2	52.28	79.971	10.8	14.84	7	GSP, STE, UCP, CPI, DCR COM, OUT
3	53.11	79.704	10.79	14.78	8	GSP, STE, COM, OUT, DCR DPI, UCP, CPI
4	53.05	78.895	10.8	14.63	6	STE, COM, DCR, DPI, UCP CPI
9	55.23	78.31	10.48	14.53	9	GSP, STE, COM, OUT, DCR, DPI, UCP, UPL, CPI
8	55.03	78.08	10.47	14.48	8	GSP, STE, COM, OUT, DCR, DPI, CPI, UPL
6	55.07	78.02	10.52	14.48	8	GSP, STE, COM, DCR, DPI, CPI, UPL, UCP
1	56.28	77.824	10.42	14.44	10	GSP, GNP, STE, COM, OUT, DCR, DPI, UCP, UPL, CPI

U.S. NEW CAR SALES

ACTUAL TO PREDICTED

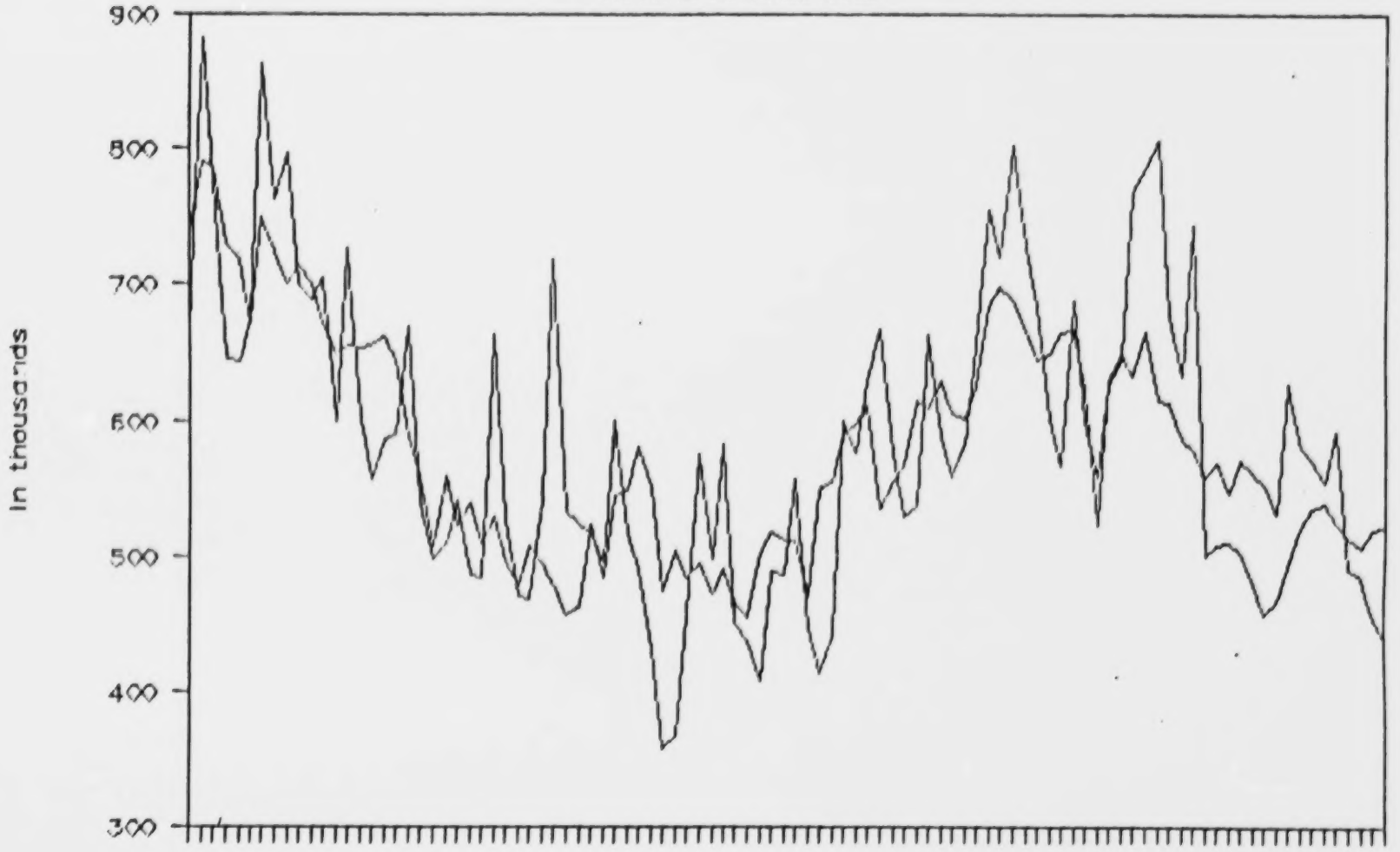

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TABLE 3B

8. **Report Writing**

Problem:

Students are often at a loss in attempting to translate MLR print-out into a lasting, written report format. Without a tangible final document, students sense no closure to their previous efforts.

Solution:

Students MUST see the relationship between the MLR statistical method and communication. The completed multiple regression process is never simply a group of "final answers" surrounded by a box. A specific writing outline, similar to that included in the present paper (see Table 4) should be established for students' use. Note that such an outline includes sections concerning literature reviews, findings and pragmatic interpretations, this latter point being of primary concern, as discussed above.

The final report should include elaborate appendices of databases graphics, charts, bibliography and reference materials. Experience has shown that the final report outline be followed exactly, for all students in all classes. Exceptions to this formality usually conclude with a less clear fundamental understanding of the MLR process by the student, and, further, results in a less judicious evaluation process for professors.

TABLE 4

BUS-355 APPLIED BUSINESS STATISTICS (form 021386)

Dr. Edward S. Balian

RESEARCH PROJECT--FORMAL OUTLINE

The research project for this class must follow the outline listed below EXACTLY. Use the Roman numerals as chapter headings; each on its own page. Use the capital letters and the respective section title within each chapter.

QUESTIONS ABOUT THE PROJECT? PLEASE ASK DURING CLASS TIME, SO ALL MAY BENEFIT FROM THE ANSWER!

Title Page (with class, section # and date)
Authorship Page (list who wrote which pages; credits for other activities, i.e., typing, library research, etc.)

CHAPTER I--INTRODUCTION

A. Overview and Problem Statement
Why was this topic selected?
Why is the study worth doing?
Who would benefit if the forecasting is accurate and valuable?
What has been written on this topic, in general?
Quote from sources which reinforce your view of this topics's importance.
Discuss any previous research done on this topic, if any.

B. Hypotheses

What do you expect to find in this study?
Which independent variables do you think will work best?
What magnitude of R-square value to you expect?
How good does R-square probably need to be for you to feel it will be really useful?
How good does SE-est probably need to be for you to feel it will be really useful?
WHY do you expect the above results? Relate your rationale to Chapter I, Section A if possible.

C. Data Sources

List, in standard reference style, all data sources for the study. Sources could include: books, journals, government publications, company files, interviews,etc. You must clearly identify each variable and its source.

CHAPTER II-FINDINGS CONCLUSIONS AND RECOMMENDATIONS

A. Findings

In order of each run, explain the results STATISTICALLY, as if you were teaching it to your readers. Compare and contrast the various runs you made, in terms of the statistical output. Discuss each run in the same numerical order throughout the report. Keep this discussion statistical; do not conclude from the findings.

B. Conclusions
What do you conclude from the above findings? In other words, what do the findings mean, in a PRACTICAL sense to you and/or management?
What are the implications to you/management?
Is the forecast model useful? If yes, explain.
If no, explain why not and what might improve it.

C. Recommendations
What were the study's limitations?
What do you wish you had done differently?
What advice to you have for future forecasters of this particular topic?

CHAPTER III-SUMMARY TABLES, GRAPHICS and PRINT-OUTS

In this chapter include all summary tables, charts and graphs first, followed by all print-outs. The print-outs should be clearly labeled as to "Run number" and in consistent order with the Findings and Conclusion sections above.

Here's your "big chance" to get fancy with color charts, but don't get carried away!

REFERENCES

In this section, list all references, including data sources, in a standard reference style. See the Madonna College Writing Style Guide or the APA Writing Style Guide, both available in the Madonna library or bookstore.

DATA DISK

A COPY of the data disk should be firmly attached to a blank page and inserted at the end of the report. You may get this disk back within the first 3 weeks of the following term from my office.

Grading of the research projects:

On the class curve, an evaluation is done across these seven factors, all with equal weight:
1. A creative forecasting idea with utilitarian purpose
2. Overall writing style

3. Quality of the independent variables selected
4. The X to N ratio applied
5. The quality/accuracy/time frame of data collection
6. Quality of references
7. Quality of graphics, summary tables, graphics

An outstanding project or segment therein will result in a half-grade (5 point) addition to the student's final point total. As in the real business world, you are competing against each other in "quality"! Inadequate projects or segments therein, will result in a grade of NC or I.

History has shown most projects to be 15 to 20 pages in length for Chapters I and II. Use standard (reasonable) margins; double spacing.

Tips of the Trade:

Don't "put off" the library research OR data collection/entry.

Reserve terminal time well ahead. Be prepared with all your data (or at least most of it) written out in a matrix form before going to the computer lab. Don't waste time re-arranging data while behind the terminal.

Use the reference librarian to assist you in a topic search; don't cut this time too close.

Attend a Madonna College Research Clinic if at all possible. (See reference librarian for details.)

Expect disasters! Build into your plan plently of "slack time" in case of unexpected problems.

If working as a team, divide the work fairly and monitor each other's progress.

Keep a back-up copy of your data disk. This requires you to buy a second disk, but it's worth it. Lab personnel can copy your data disk to your back-up disk using Super Disk Copy in a matter of seconds. Never store both data disks together. Do not add to the original data disk without re-copying the back-up each time.

Never, EVER, hand in the only copy of the report. It is you/your team's responsibility to maintain document and disk copies!

Last, but not least, if you are experiencing SERIOUS problems, inform your professor as early as possible. Don't wait until week 12 to discover a "disaster".

Hope this outline helps; your comments are appreciated.

9. Oral Presentations to Peers

Problem:

Students feel that they may only understand the topic in written terms, within only the context of their final report. Other students may feel that they understand MLR but not really well enough to present it to anyone.

Solution:

Each student (or team) should orally present to his class an executive summary of the MLR report. In the case of group projects, the oral presentation can be evenly divided among the group members. Hand-outs must always accompany the presentations and should include materials such as the earlier described MLR Summary Table, a listing of all variables, and a background section on the particular MLR problem at hand, from an applied "real world" perspective.

It is important that instructors relate to students the pragmatic importance of oral presentations in the MLR area (or any other). Stressing the communication element helps students realize the difference between "knowing" and "memorizing" (i.e., critical thinking) and, additionally, further highlights the utilitarian aspects of the procedure.

10. Peer Evaluations of the Oral Presentations

Problem:

Students sometimes feel that the only MLR project they really understand is their own. Second, students, at this stage, often are in need of immediate feedback from their audiences.

Solution:

Here a two-fold problem is solved by peer evaluation. During the oral presentation exercise described earlier, the peer audience (the remaining class) listens carefully, takes notes, and partakes in a question/answer session following the report. Peers then evaluate the performance of the presenter(s) on formalized forms, using a Likert-type rating scale (1-5); space is also allotted for open-ended comments. Students identify themselves only to the instructor, using the last four digits of their social security number.

Two forms of graded evaluations could occur. First the instructor can review the evaluations and comments and prepare a typed "peer feedback summary" for the presenters the following session. In many cases, class mean scores for the presentation delivery, graphics used and question/answer poise can be used in part toward a final grade for the presenters (See Table 5). Secondly, instructors may wish to "evaluate the evaluations" and count this toward a student-evaluator's final course grade.

This two-fold evaluation process insures that the student presenters and their classmates alike, must understand differing applications, and topics in MLR and remain involved, from both sides of the podium, in the learning process.

Summary

In conclusion, practical experience has demonstrated significant success in teaching MLR via the aforementioned "ten essentials." The overall academic goal is to motivate students into higher level learning skills, while they, more specifically, learn of the practical power and utility of MLR in the real world.

The author would appreciate comments from other academicians in the field.

TABLE 5

Bus-355 4-15-87

K-Mart Presentation Class Grading Summary

Class grading:

Presentation	6.475
Graphics	5.65
Q/A	7.80

Improvement Comments:

Let every member of the group be noticed: a little tight.

Well aware of the topic: good job

Presentation was good; a lot of numbers came out

Informative; hand-outs explicit

More visual aids needed

Too quick on presentation; needs graphics

Explain findings more clearly; good speaking order

Don't sit on desk; need visual aids

Lost when speakers changed

Unprofessional dress; needed visual aids

Needed more practice in presenting the data; more time no excuse. we all had the same time limitations and work schedules; good q/a

Group seemed uncomfortable with presentation; y was too complex to effectively forecast; we were warned about that

Needs to be more professional in front of class

Too monotone; crack a smile and relax.

No graphics; knowledgeable of subject

Summary table a little confusing; good q/a work

More organization needed in group; good understanding of MLR and topic

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